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(54) **SYSTEM CONTROLLER FOR INTEGRATED LIGHTING CONTROL PANELS**

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(51) **Int. Cl.**
H02J 3/14 (2006.01)

(52) **U.S. Cl.** **307/31**; 307/38; 700/19

(58) **Field of Classification Search** 700/19; 200/331; 307/31, 38

See application file for complete search history.

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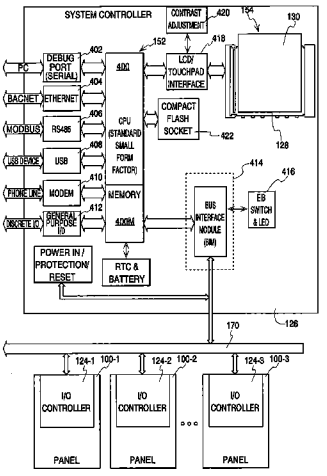
(57) **ABSTRACT**

An electrical distribution system is provided for selectively connecting an electrical power source to load devices comprising a plurality of panelboards each having a plurality of load circuit positions. A plurality of pairs of circuit breakers and switching devices are each mounted in one of the load circuit positions. Each pair is electrically connected between an electrical power source and a load device for selectively delivering electrical power to load devices. An I/O controller is mounted in the panelboard for controlling operation of the switching devices. The I/O controller includes a communication circuit. A system controller is connected to each I/O controller communication circuit and comprises a programmed controller for commanding operation of the I/O controllers.

20 Claims, 7 Drawing Sheets



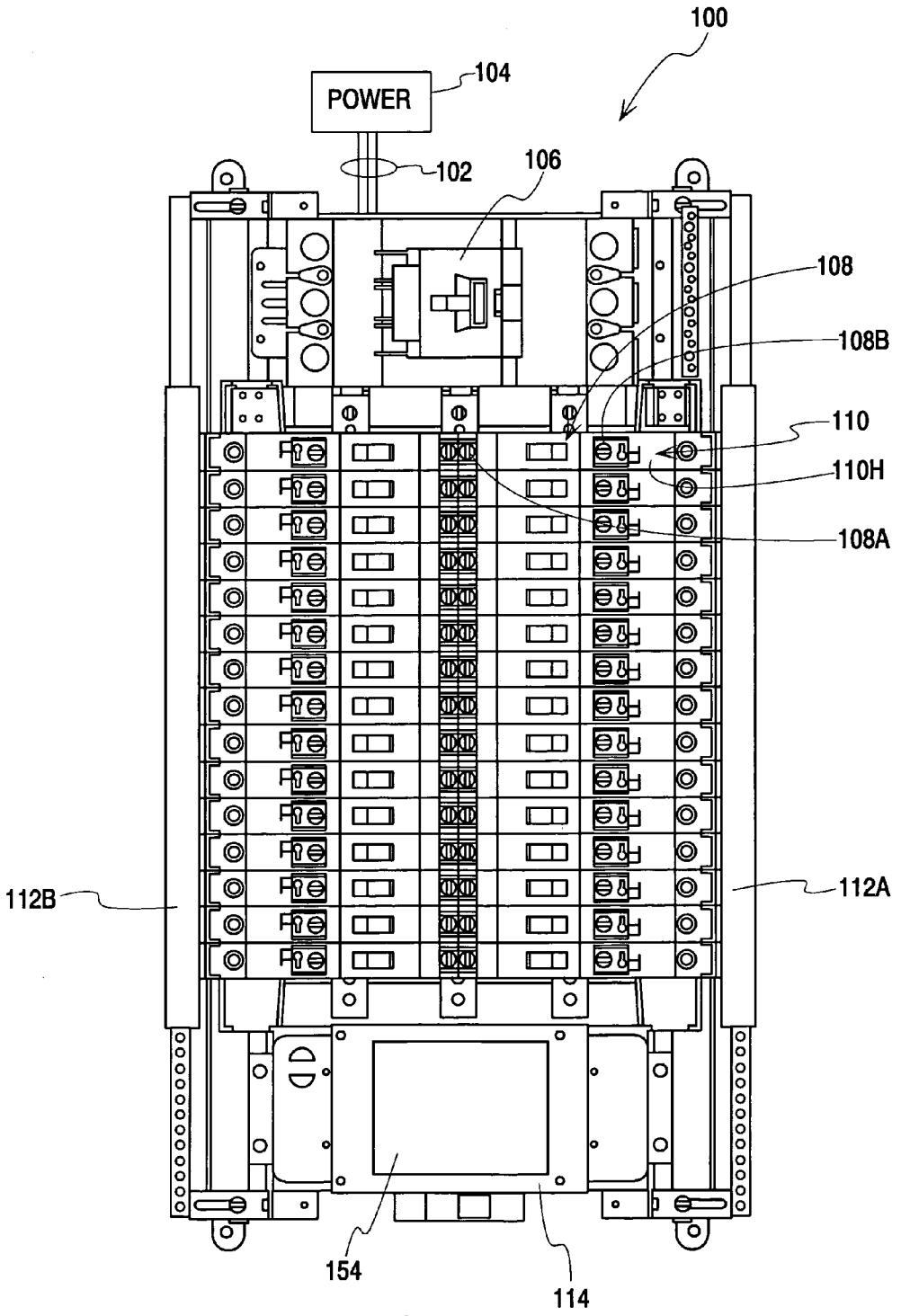


Fig. 1

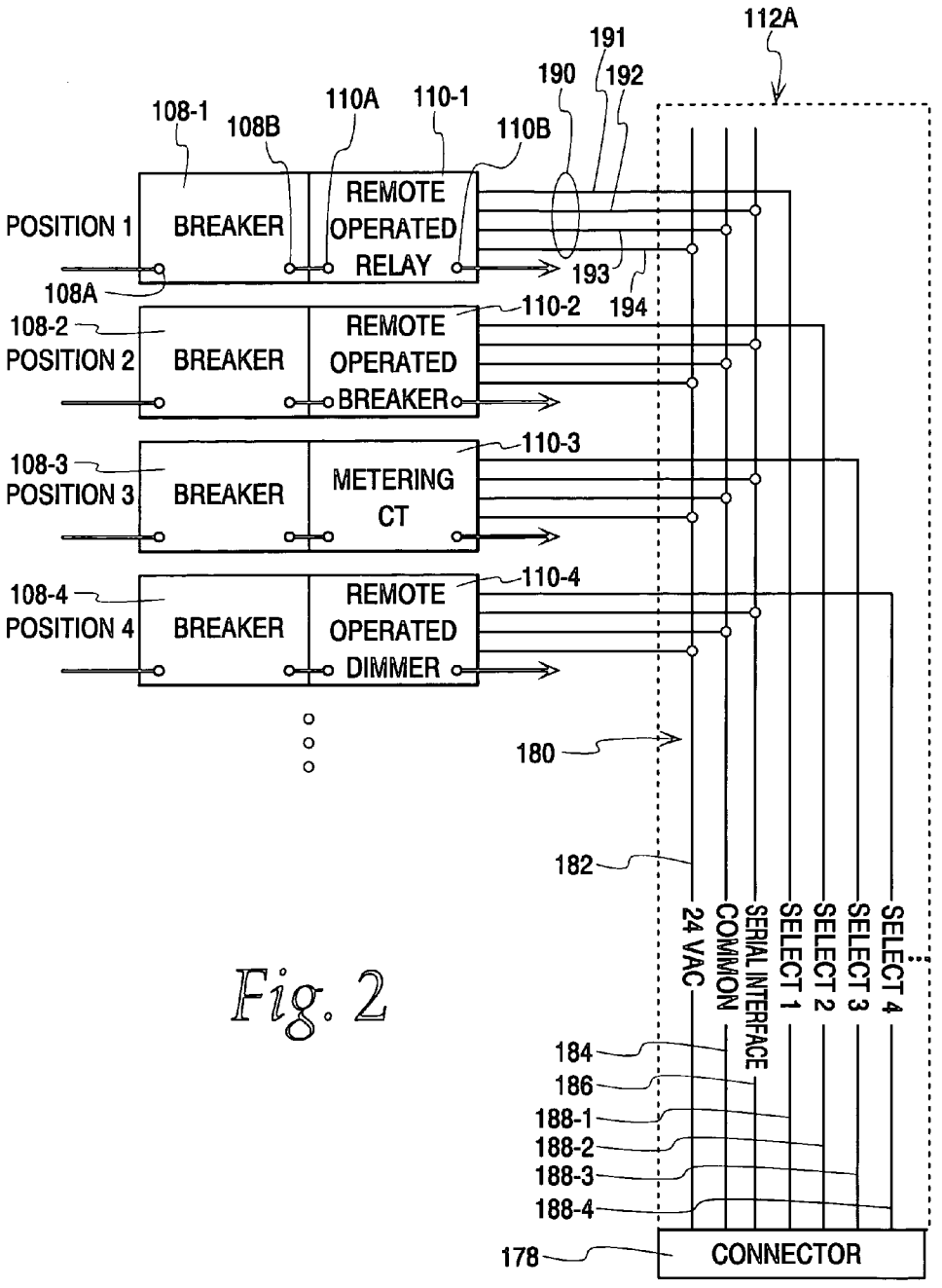

112A
191
190
192
108-1
108B
110A
110-1
110B
POSITION 1
BREAKER
REMOTE OPERATED RELAY
193
194
108A
108-2
POSITION 2
BREAKER
110-2
REMOTE OPERATED BREAKER
108-3
POSITION 3
BREAKER
110-3
METERING CT
108-4
POSITION 4
BREAKER
110-4
REMOTE OPERATED DIMMER
180
182
24 VAC
COMMON
SERIAL INTERFACE
SELECT 1
SELECT 2
SELECT 3
SELECT 4
184
186
188-1
188-2
188-3
188-4
178
CONNECTOR

Fig. 2

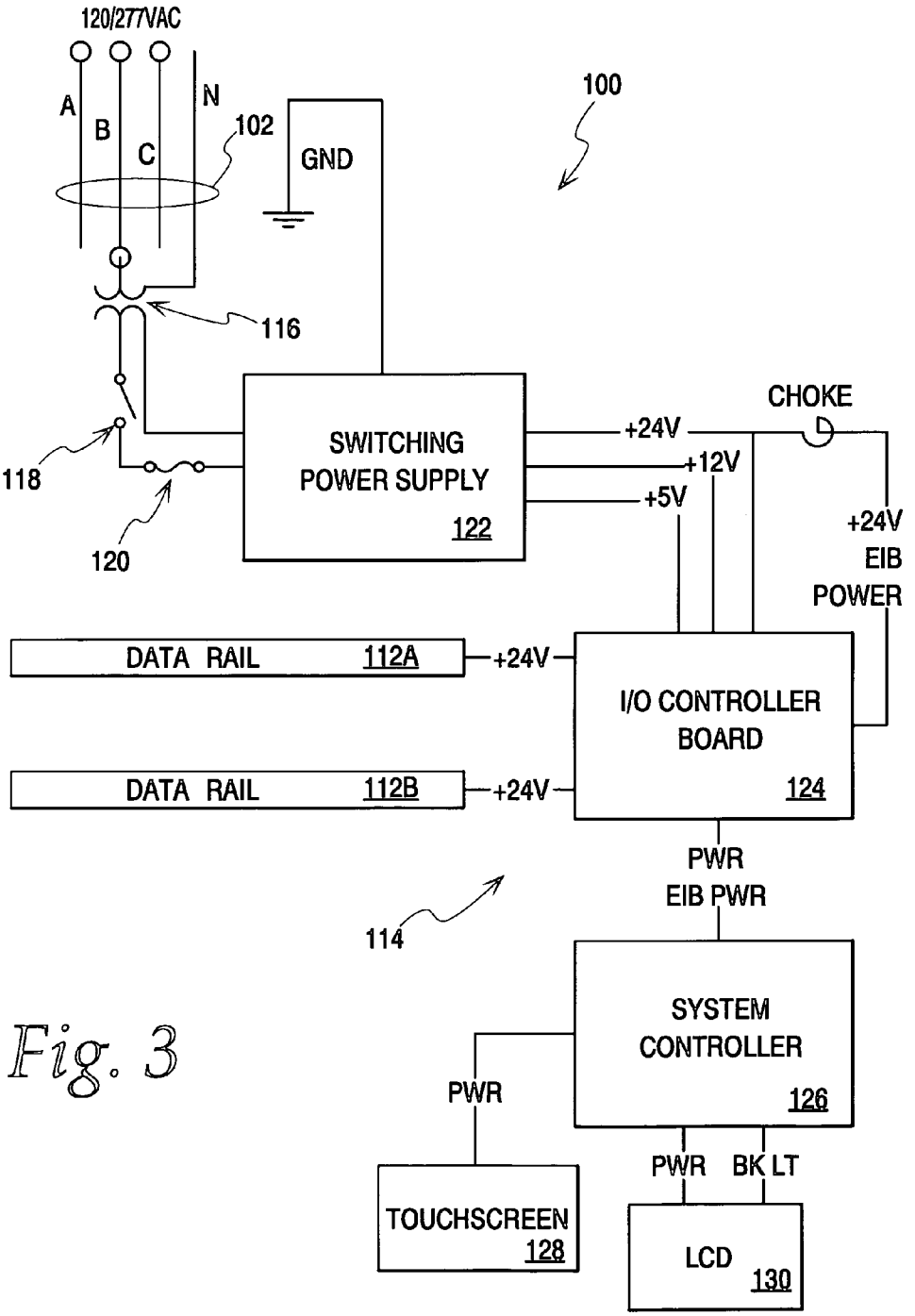

120/277VAC
A
B
C
N
102
GND
100
116
118
120
SWITCHING
POWER SUPPLY
122
+24V
+12V
+5V
CHOKE
+24V
EIB
POWER
DATA RAIL 112A
+24V
DATA RAIL 112B
+24V
I/O CONTROLLER
BOARD
124
PWR
EIB PWR
114
SYSTEM
CONTROLLER
126
PWR
PWR
BK LT
TOUCHSCREEN
128
LCD
130

Fig. 3

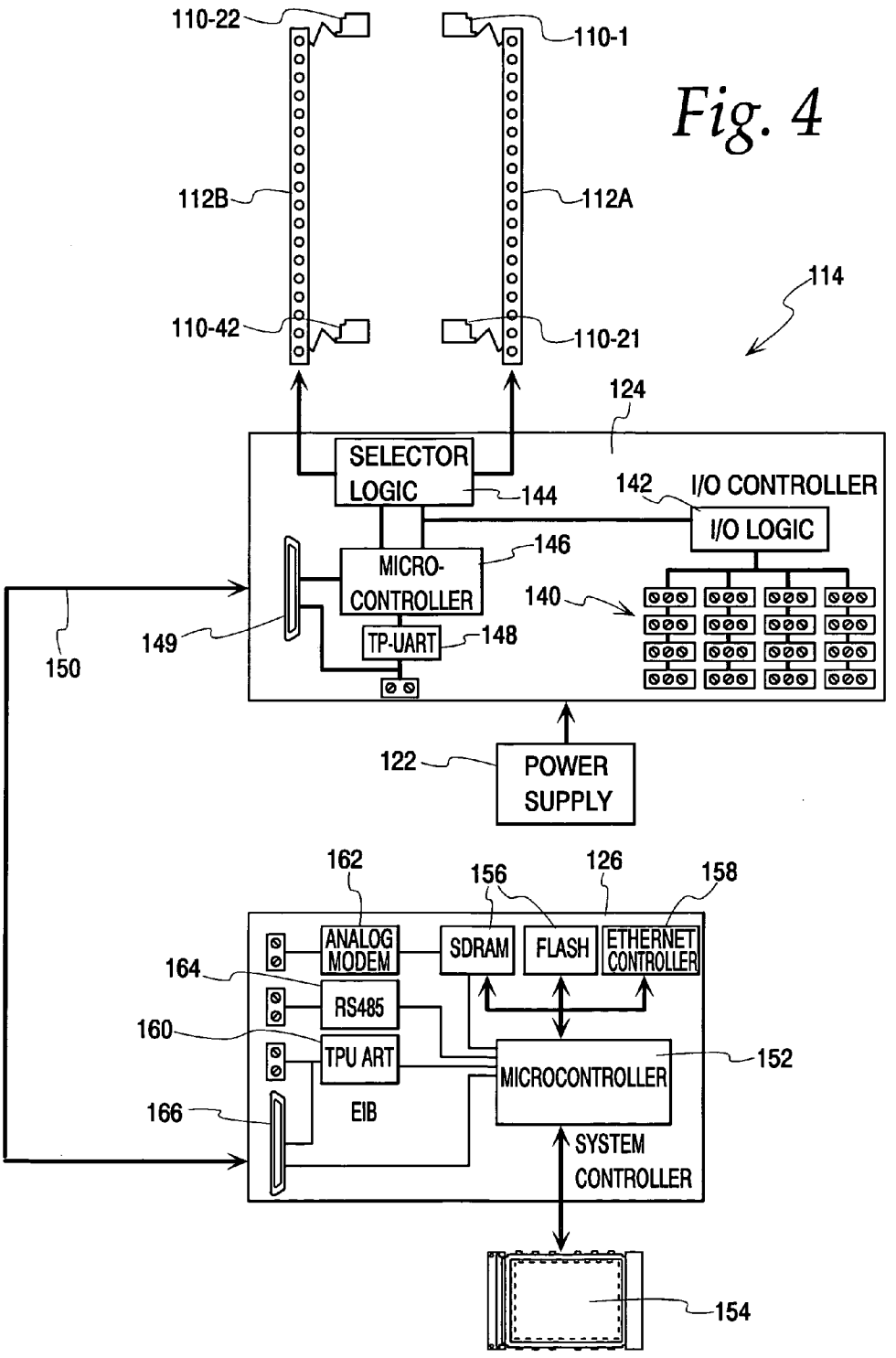

110-22
110-1
112B
112A
110-42
110-21
114
124
SELECTOR LOGIC
144
142
I/O CONTROLLER
I/O LOGIC
146
MICRO-CONTROLLER
140
TP-UART
148
149
150
122
POWER SUPPLY
162
156
126
158
ANALOG MODEM
SDRAM
FLASH
ETHERNET CONTROLLER
164
RS485
160
TPU ART
152
MICROCONTROLLER
166
EIB
SYSTEM CONTROLLER
154

Fig. 4

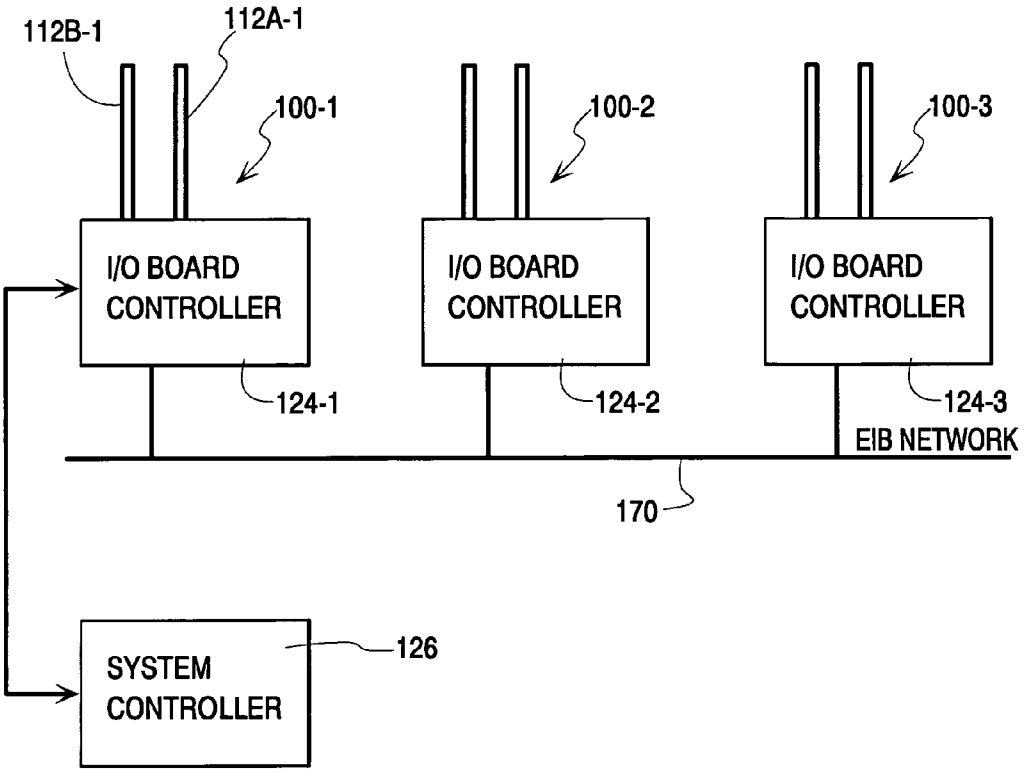

112B-1
112A-1
100-1
100-2
100-3
I/O BOARD CONTROLLER
I/O BOARD CONTROLLER
I/O BOARD CONTROLLER
124-1
124-2
124-3
EIB NETWORK
170
SYSTEM CONTROLLER
126

Fig. 5

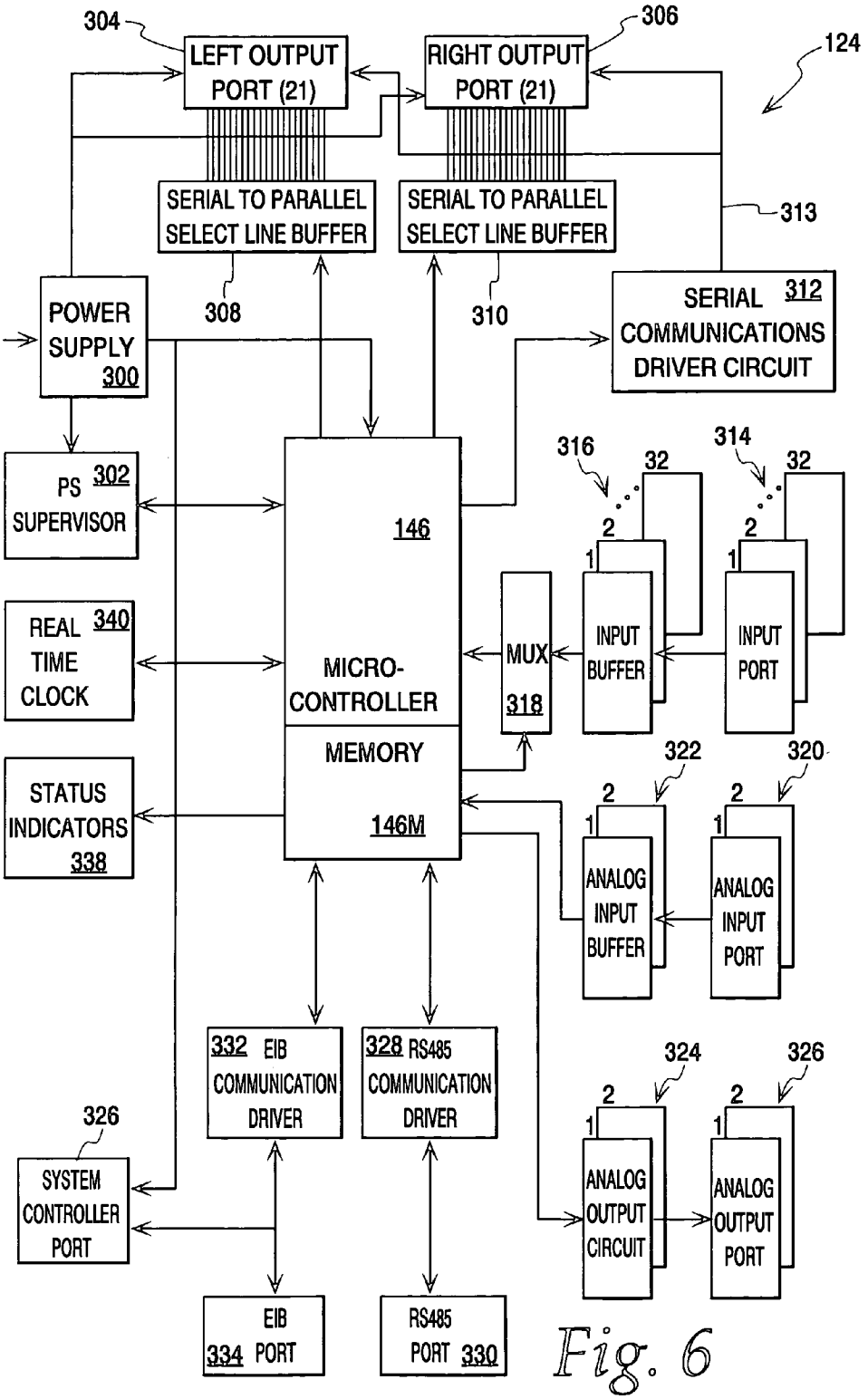

304
LEFT OUTPUT PORT (21)
306
RIGHT OUTPUT PORT (21)
124
SERIAL TO PARALLEL SELECT LINE BUFFER
SERIAL TO PARALLEL SELECT LINE BUFFER
313
POWER SUPPLY 300
308
310
SERIAL 312 COMMUNICATIONS DRIVER CIRCUIT
PS 302 SUPERVISOR
146
316
32
2
1
314
32
2
1
REAL 340 TIME CLOCK
MICRO-CONTROLLER
MEMORY
146M
MUX 318
INPUT BUFFER
INPUT PORT
STATUS INDICATORS 338
322
320
2
1
2
1
ANALOG INPUT BUFFER
ANALOG INPUT PORT
332 EIB COMMUNICATION DRIVER
328 RS485 COMMUNICATION DRIVER
324
326
2
1
2
1
326
SYSTEM CONTROLLER PORT
ANALOG OUTPUT CIRCUIT
ANALOG OUTPUT PORT
EIB 334 PORT
RS485 PORT 330

Fig. 6

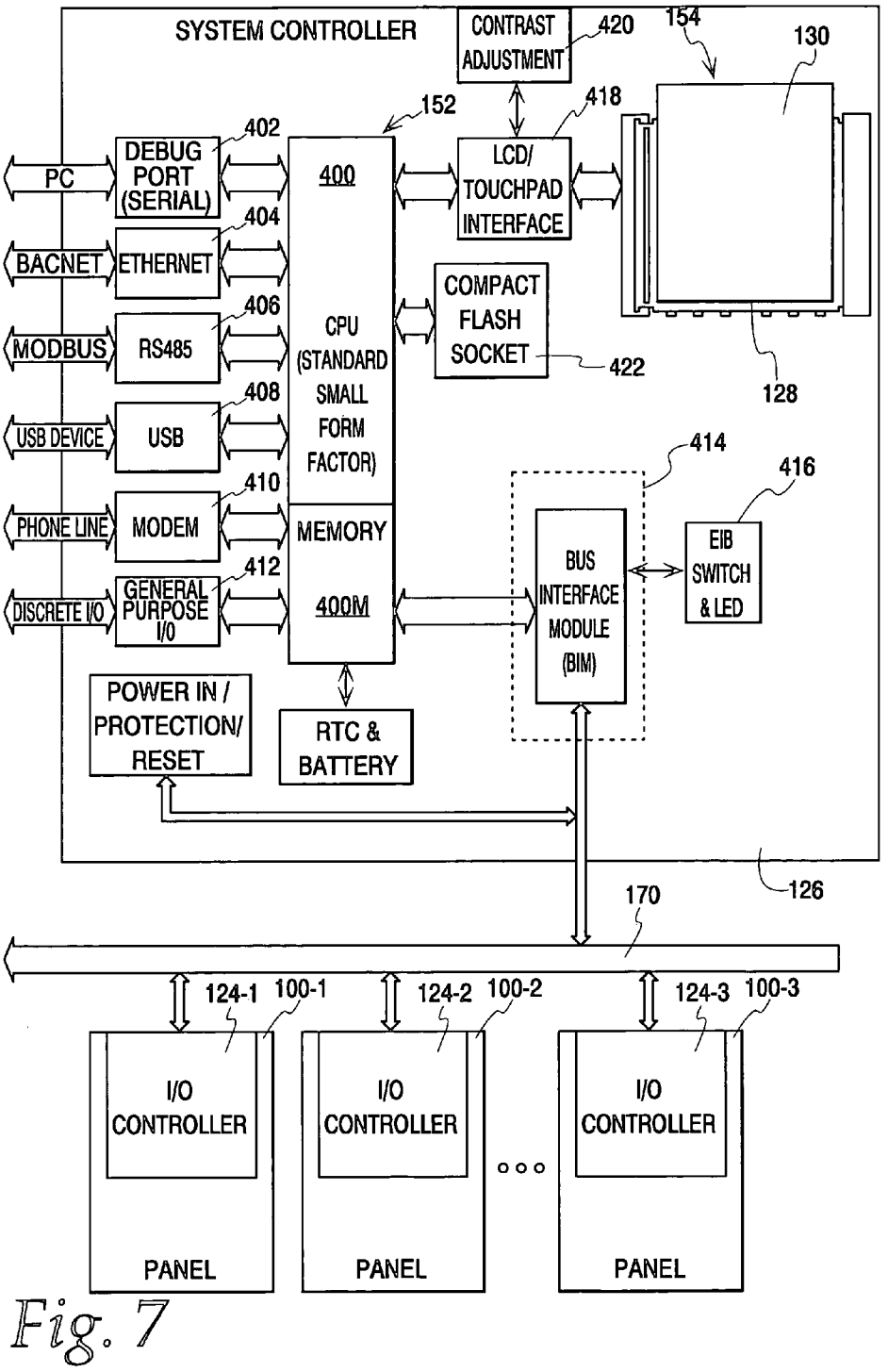

SYSTEM CONTROLLER
CONTRAST ADJUSTMENT
420
154
130
152
418
402
DEBUG PORT (SERIAL)
400
LCD/ TOUCHPAD INTERFACE
PC
404
ETHERNET
BACNET
406
RS485
MODBUS
COMPACT FLASH SOCKET
422
128
CPU (STANDARD SMALL FORM FACTOR)
408
USB
USB DEVICE
414
416
410
MODEM
PHONE LINE
MEMORY
400M
BUS INTERFACE MODULE (BIM)
EIB SWITCH & LED
412
GENERAL PURPOSE I/O
DISCRETE I/O
POWER IN / PROTECTION/ RESET
RTC & BATTERY
126
170
124-1
100-1
124-2
100-2
124-3
100-3
I/O CONTROLLER
I/O CONTROLLER
I/O CONTROLLER
PANEL
PANEL
PANEL

Fig. 7

SYSTEM CONTROLLER FOR INTEGRATED LIGHTING CONTROL PANELS

CROSS REFERENCE TO RELATED APPLICATIONS

This application claims priority of provisional application No. 60/826,687 filed Sep. 22, 2006, the contents of which is incorporated by reference herein.

FIELD OF THE INVENTION

This invention relates generally to residential and commercial electrical power distribution panels and components, and more particularly, to a system controller for integrated distribution panels in an electrical power distribution system.

BACKGROUND OF THE INVENTION

Circuit breaker panels are used to protect electrical circuitry from damage due to an overcurrent condition, such as an overload, a relatively high level short circuit, or a ground fault condition. To perform that function, circuit breaker panels include circuit breakers that typically contain a switch unit and a trip unit. The switch unit is coupled to the electrical circuitry (i.e., lines and loads) such that it can open or close the electrical path of the electrical circuitry. The switch unit includes a pair of separable contacts per phase, a pivoting contact arm per phase, an operating mechanism, and an operating handle.

In the overcurrent condition, all the pairs of separable contacts are disengaged or tripped, opening the electrical circuitry. When the overcurrent condition is no longer present, the circuit breaker can be reset such that all the pairs of separable contacts are engaged, closing the electrical circuitry.

In addition to manual overcurrent protection via the operating handle, automatic overcurrent protection is also provided via the trip unit. The trip unit, coupled to the switch unit, senses the electrical circuitry for the overcurrent condition and automatically trips the circuit breaker. When the overcurrent condition is sensed, a tripping mechanism included in the trip unit actuates the operating mechanism, thereby disengaging the first contact from the second contact for each phase. Typically, the operating handle is coupled to the operating mechanism such that when the tripping mechanism actuates the operating mechanism to separate the contacts, the operating handle also moves to a tripped position.

Switchgear and switchboard are general terms used to refer to electrical equipment including metal enclosures that house switching and interrupting devices such as fuses, circuit breakers and relays, along with associated control, instrumentation and metering devices. The enclosures also typically include devices such as bus bars, inner connections and supporting structures (referred to generally herein as "panels") used for the distribution of electrical power. Such electrical equipment can be maintained in a building such as a factory or commercial establishment, or it can be maintained outside of such facilities and exposed to environmental weather conditions. Typically, hinge doors or covers are provided on the front of the switchgear or switchboard sections for access to the devices contained therein.

In addition to electrical distribution and the protection of circuitry from overcurrent conditions, components have been added to panels for the control of electrical power to loads connected to circuit breakers. For example, components have been used to control electrical power for lighting.

One system used for controlling electrical power to loads utilizes a remote-operated circuit breaker system. In such a system, the switch unit of the circuit breaker operates not only in response to an overcurrent condition, but also in response to a signal received from a control unit separate from the circuit breaker. The circuit breaker is specially constructed for use as a remote-operated circuit breaker, and contains a motor for actuating the switch unit.

In an exemplary remote-operated circuit breaker system, a control unit is installed on the panel and is hard-wired to the remote-operated circuit breaker through a control bus. When the switch unit of the circuit breaker is to be closed or opened, an operating current is applied to or removed from the circuit breaker motor directly by the control panel. Additional, separate conductors are provided in the bus for feedback information such as contact confirmation, etc., for each circuit breaker position in the panel. The control unit contains electronics for separately applying and removing the operating current to the circuit breakers installed in particular circuit breaker positions in the panel. The panel control unit also has electronics for checking the state of the circuit breaker, diagnostics, etc. One advantage of that system is that the individual circuit breakers can be addressed according to their positions in the panel.

Typically, a power distribution such as a lighting control panel includes local control of the individual switch units. In a stand alone system, a control module is incorporated in the panel for controlling the individual switch devices. With a plurality of panels, such systems use a single control module for the plurality of panels. As such, operation of the individual panels can be dependent on a single control module such that failure of the control module or communications between panels, can interfere with proper operation.

The present invention is directed to improvements in electrical distribution systems, such as lighting control panels

SUMMARY OF THE INVENTION

In accordance with the invention, there is provided an electrical distribution system including an integrated system controller capable of controlling a plurality of electrical distribution panels.

In accordance with one aspect of the invention, there is disclosed an electrical distribution system for selectively connecting an electrical power source to load devices. The system comprises a plurality of panels. Each panel comprises a plurality of switching devices mounted in the panel. Each switching device is for connection in a branch circuit to a load device for selectively delivering electrical power to the load device. An input/output (I/O) controller is mounted in the panel and is operatively connected to each of the switching devices for controlling operation of the switching devices. The I/O controller includes a communication circuit. A system controller is connected to each I/O controller communication circuit and comprises a programmed controller for commanding operation of the I/O controller.

It is a feature of the invention that the system controller is operable to independently configure operation of each of the I/O controllers.

It is another feature of the invention that the system controller is operable to download switching schedules to each of the I/O controllers.

It is a further feature of the invention that the system controller is operable to download commands to each of the I/O controllers to control operation of individual select ones of the plurality of remote operated devices.

It is still a further feature of the invention that the system controller is operable to download commands to each of the I/O controllers to control operation of a plurality of the remote operated devices in a zone configuration.

It is still another feature of the invention that the system controller receives status information from each of the I/O controllers indicating operating condition of the plurality of remote operated devices.

It is yet another feature of the invention that the system controller comprises a user interface for configuring operation of the I/O controllers. The user interface may display information from the plurality of panels in a graphical display.

It is still a further feature of the invention that the system controller is mounted in one of the plurality of panels.

It is an additional feature of the invention that the programmed controller comprises a communication circuit for communication with external networks.

There is disclosed in accordance with another aspect of the invention an electrical distribution system for selectively connecting an electrical power source to load devices comprising a plurality of panelboards each having a plurality of load circuit positions. A plurality of pairs of circuit breakers and switching devices are each mounted in one of the load circuit positions. Each pair is electrically connected between an electrical power source and a load device for selectively delivering electrical power to load devices. An I/O controller is mounted in the panelboard for controlling operation of the switching devices. The I/O controller includes a communication circuit. A system controller is connected to each I/O controller communication circuit and comprises a programmed controller for commanding operation of the I/O controllers.

Further features and advantages of the invention will be readily apparent from the specification and from the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an elevation view of a power distribution panel according to the invention;

FIG. **2** is a block diagram illustrating pairs of circuit breakers and remote operated devices of the power distribution panel of FIG. **1**;

FIG. **3** is a block diagram of the power distribution panel of FIG. **1**;

FIG. **4** is an expanded schematic/block diagram of the power distribution panel of FIG. **1**;

FIG. **5** is block diagram of a multiple panel system in accordance with the invention;

FIG. **6** is a detailed block diagram of the I/O controller of FIG. **3**; and

FIG. **7** is a detailed block diagram of the system controller of FIG. **3**.

DETAILED DESCRIPTION OF THE INVENTION

An electrical distribution system, such as an integrated lighting control system, in accordance with the invention permits a user to control power circuits typically used for lighting, as well as circuits for resistive heating or air conditioning, using an integrated system controller. Control may include on/off switching, dimming and metering. The electrical distribution system may be as is generally described in U.S. application Ser. No. 11/519,727, filed Sep. 12, 2006, the specification of which is incorporated by reference herein.

Referring to FIG. **1**, a lighting control system in accordance with the invention comprises a lighting control panel **100**. The panel **100** may comprise a Siemens type P1panelboard, although the invention is not limited to such a configuration. Line power enters the panel **100** through power source cables **102** connected to a source of power **104**. Line power may, for example, be a three phase 480Y277, 240 or 120VAC power source, as is conventional. The cables **102** are electrically connected to an input side of a main breaker **106**. The main breaker **106** distributes line power to individual circuit breakers **108** in a conventional manner. How the power is distributed depends on design of the individual circuit breakers **108**, as will be apparent to those skilled in the art. The power is distributed to the line side of individual circuit breakers **108**. The panel **100** may be configured to accept up to forty-two individual circuit breakers **108**, although only thirty are shown in the embodiment of FIG. **1**. Each circuit breaker may be of conventional construction and may be, for example, a Siemens BQD circuit breaker. Each circuit breaker **108** includes a line terminal **108**A receiving power from the main breaker **106** and a load terminal **108**B conventionally used for connecting to a load circuit.

For simplicity of description, when a device such as a circuit breaker **108** is described generally herein the device is referenced without any hyphenated suffix. Conversely, if a specific one of the devices is described it is referenced with a hyphenated suffix, such as **108-1**.

In accordance with the invention, each load circuit to be controlled also has a remote operated device **110**, such as a relay, a meter or a dimmer. The term remote operated device as used herein includes any other devices that controls, monitors or may otherwise be used in a load circuit, in accordance with the invention. While in a preferred embodiment, the remote operated device **110** is a separate component from the circuit breaker **108**, the term "remote operated device" as used herein encompasses devices integral with the circuit breaker. The remote operated devices **110** are also connected to data rails **112**A and **112**B. A panel controller **114** controls the remote operated devices **110** through connections provided via the data rails **112**A and **112**B, as discussed below.

The remote operated device **110** includes a housing **110**H encasing an auxiliary set of contacts that can be remotely operated to open and close a lighting circuit. The device **110** is attached to the load side of a circuit breaker **108** within a panel **100** using a conductor tab, i.e, the terminal **110**A, inserted into the breaker lug **108**B. The load terminal **110**B comprises a lug of the same size as the breaker lug **108**B for connecting to a wire to be connected to the load device. The device housing **110**H is configured to mount in a Siemens type P1 panelboard, although the invention is not limited to such a configuration.

Referring to FIG. **2**, a block diagram illustrates four circuit breakers **108-1**, **108-2**, **108-3** and **108-4**, and respective associated remote operated devices **110-1**, **110-2**, **110-3** and **110-4**. In the illustrated embodiment, the first device **110-1** comprises a relay, the second device **110-2** comprises a breaker, the third device **110-3** comprises a current transformer, and the fourth device **110-4** comprises a dimmer. As is apparent, any combination of these remote operated devices **110** could be used. Each remote operated device **110** includes an input terminal **110**A electrically connected to the associated circuit breaker load terminal **108**B, and an output terminal **110**B for connection to a load device.

Referring to FIG. **3**, a block diagram of the lighting control panel **100** is illustrated. Power from the lines **102** is provided via an isolation transformer **116**, power switch **118** and fuse **120** to a switching power supply **122**. The panel controller

114 comprises an input/output (I/O) controller 124 and optionally a system controller 126. The power supply 122 provides isolated power to all of the control components including the I/O controller board 124, the system controller 126, and the remote operated devices 110, see FIG. 1, via the data rails 112A and 112B. The I/O controller 124 and system controller 126 each have DC-DC converters deriving regulated DC voltage levels as required from the main DC output of the power supply 122. The power supply 122 also provides 24 volts to the remote operated devices 110. The system controller 126 is operatively connected to a touch screen 128 and an LCD 130.

In one embodiment of the invention, shown in FIG. 4, the panel controller 114 functions as a single panel stand alone system. The I/O controller 124 supplies power and control signals through the rails 112A and 112B to the remote operated devices, four of which, 110-1, 110-21, 110-22 and 110-42, are illustrated. A user interface and high level scheduling and control are provided by the system controller 126.

The I/O controller 124 provides discrete inputs to the controller 114 from dry contact switches, such as wall switches, (not shown) which can be connected to discrete input terminals 140. The terminals 140 are organized as two inputs and a common. The inputs to the terminals 140 are detected by dry contact I/O logic 142. A selector logic block 144 generates selector line signals and serial communications to the remote operated devices 110 via the data rails 112. The logic blocks 142 and 144 are operatively associated with a microprocessor or microcontroller 146. A TP-UART integrated circuit 148 provides an EIB (European Installation Bus) interface. A connector 149 allows mating directly to the system controller 126 via a cable 150.

The system controller 126 provides the user with an application to implement lighting schedules, organize devices into logical groups, manage the inputs, and obtain status information. The system controller 126 includes a microprocessor 152 operatively connected to a user interface 154 in the form of an integrated touch screen 128 and LCD 130, see FIG. 3. The microprocessor 152 is also connected to memory devices 156 and an ethernet controller 158. A TP-UART circuit 160 provides an EIB interface while additional interfaces are provided via an analog modem 162 and RS 485 interface circuit 164. A connector 162 is provided for connection to the cable 150.

In another embodiment, shown in FIG. 5, multiple lighting control panels 100-1, 100-2 and 100-3 are configured to work as a single unit with the first panel 100-1 being configured as a master, and the other panels 100-2 and 100-3 configured as slaves. To configure the first panel 100-1 as a master, the system controller 126 is used, as described above relative to FIG. 4. The slave panels 100-2 and 100-3 contain no system controller. Instead, an EIB bus 170 interconnects the I/O controller boards 124-1, 124-2 and 124-3 to receive commands from the system controller 126.

Referring again to FIG. 2, a data rail 112 is illustrated schematically. The data rail 112 is mechanically attached directly to the interior of the lighting control panel 100. The data rail 112 comprises a shielded communication bus including a ribbon connector 178 having twenty-five to twenty-nine wires to be routed to the I/O controller board 124. The ribbon connector 178 typically has twenty-six wires, two for power connection, two for ground connection, one for the serial line and up to twenty-one select lines, one for each remote operated device 110. Each data rail 112 provides a barrier to isolate the class 1 load wires from the class 2 signal wires used to manage the devices 110. The data rails 112 will connect to each device 110 via a connector that extends out of the device 110. The wires are connected to a printed circuit board 180 included traces defined as follows. A power trace 182 provides 24 volt DC power to each remote operated device 110. A common trace 184 provides a ground to each remote operated device 110. A serial interface trace 186 provides serial communication to each of the remote operated devices 110. A plurality of select line traces, four of which 188-1, 188-2, 188-3 and 188-4 are illustrated, are provided, one for each remote operated device 110. Each remote operated device 110 includes a four wire cable 190 for connection to the data rail 112. The four wires comprise a select line 191 connected to one of the select traces 188, a serial interface line 192 connected to the serial interface trace 186, a neutral wire 193 connected to the common trace 184 and a power wire 194 connected to the power trace 182.

In accordance with the invention, a unique select line is assigned to each breaker 108/remote operated device 110 pair positioned within the lighting control panel 100. Select lines are used by the I/O controller 124 to select single remote operated devices to communicate via the serial interface trace 186. For example, when the first select line 188-1 is asserted, the first remote operated device 110-1 listens for messages on the serial interface line 186. Conversely, messages on the serial interface 186 are ignored if the first select line 188-1 is not asserted. A response by any of the remote operated devices 110 to a serial command is therefore conditional on whether its particular select line is asserted. The term "asserted", as used herein, means one state of a signal designated to cause the remote operated device to listen for messages. In a preferred embodiment, the select line has "high" and "low" states, the high state being the asserted state.

The remote operated device 110, in the form of a relay, allows remote switching of an electrical branch load. The device 110 is designed to fit inside a standard electrical panel board with up to forty-two branch circuit breakers 108. The device 110 is an accessory to a branch circuit breaker 108 allowing repetitive switching of the load without effecting operation of the circuit breaker 108.

Referring to FIG. 6, the circuitry for the I/O controller 124 is illustrated in greater detail in block diagram form. The I/O controller 124 is powered from the external power supply 122, see FIG. 3, that feeds a power supply 300. The power supply 300 produces the voltages needed by the microcontroller 146 and all the other circuits making up the I/O controller 124. The microcontroller 146 may, for example, comprise a TI MSP430 microcontroller and associated memory 146M, such as flash memory or ROM memory, for strong operating programs and data, as is conventional. A power supply supervisor 302 monitors voltage and sends a reset to the microcontroller 146 if a voltage falls out of tolerance. The forty two outputs for the individual remote operated devices 110, see FIG. 2, are divided into twenty-one left side outputs at a left output port 304 and twenty-one right side outputs at a right output port 306. Serial to parallel select line buffers 308 and 310 develop separate select or enable signals for each output device 110 from the microcontroller 146 to the respective output ports 304 and 306. The two serial to parallel blocks 308 and 310 are identical so that the same clock can drive both sides, further reducing output pins needed from the microcontroller 146.

A serial communication driver circuit 312 is used to isolate and drive a single wire serial communication line 313 from the microcontroller 146 to the output ports 304 and 306. Voltage and ground from the power supply 300 are also connected to the output ports 304 and 306. The single wire communication line 313 connects to each remote operated device 110, as described above, to transmit and receive com-

mands and data. The serial communication driver circuit **312** provides necessary isolation and protection such that in the event of an individual remote operated device failure, the remainder of the devices continued to operate properly.

The I/O controller **124** has thirty-two discrete inputs connected to input ports **314**. Each input port **314** is individually protected, conditioned, and buffered at input buffers **316** connected to the microcontroller **146** via a multiplexer **318** to allow reading eight inputs at a time. Since an input can be connected to a variety of devices, such as several different types of switches and occupancy sensors from different manufacturers, each input is read under different conditions controlled by the microcontroller **146**. By reading the input twice, once with the input bias high and then again with the input bias low, the microcontroller **146** can determine a change of state regardless of whether the input is a switch contact or a positive DC voltage.

A pair of analog input ports **320** are used for reading analog inputs, such as photo cells. The ports **320** consists of three terminal connections, two analog inputs on the outside with a ground terminal in the center. The analog inputs are individually buffered at analog input buffers **322** and routed to analog inputs of the microcontroller **146**. Analog outputs from the microcontroller **146** are created by sending a pulse width modulated signal to a pair of analog output circuits **324**. The analog output circuits **324** converts the PWM signal to a DC voltage corresponding to the duty cycle of the PWM. The outputs are then connected to analog output port **326**. The analog output ports **326** may comprise three terminals with the two analog outputs connected to the two outside terminals with a ground terminal in the center.

The illustrated I/O controller **124** includes two means of a communication. The first is a master/slave protocol using an RS485 communication drive **328** with configurable termination and bias connected to an RS485 port **330**. The RS485 port **330** has both an in and out connectors for daisy chaining RS485 connections. The second form of communication is an EIB or Konnex distributed processing protocol using an EIB communication driver **332** connected to an EIB port **334**. The EIB port **334** is a two pin connection for attaching a twisted pair connector. In addition, the EIB communication lines connect to a system controller port **336** along with voltage from the power supply **300**. This port is used to communicate with the system controller **126** via the cable **150** connected to the connector **148**, see FIG. **4**, discussed above. As discussed above relative to FIG. **5**, the system controller **126** configures a system of multiple panels, sets up time schedules, maps inputs to outputs, and provides other building automation functions.

The microcontroller **146** can send signals to various types of status indicators **338** such as LEDs to show communications OK, operating properly, low voltage, etc. If a time schedule has been configured in the I/O controller **124**, a real time clock **340** provides the ability to activate outputs based on time of day without intervention from a system controller or other building automation system.

Each lighting control panel **100** is capable of stand alone operation. When a system controller **126** is connected to a network of panels **100**, the panels **100** can be independently configured, mapped to switch devices in other panels, operate on changing time schedules, communicate on various building automation networks, and display information from several panels on a local graphical display.

FIG. **7** illustrates a block diagram of the system controller **126** in a multiple panel system. The system controller **126** is controlled by the microcontroller **152** in the form of a standard form factor embedded CPU module **400** including appropriate memory circuits **400**M, as is conventional. Various means for communication are provided with the system controller **126**. A debug port **402** is a serial communication link similar to RS 232 used to load and debug the CPU **400**. An ethernet controller **404** is capable of interfacing with Bacnet or the internet. An RS485 port **406** can be used with Modbus protocol. A USB interface **408** is provided for interfacing to a memory stick or other USB devices. A modem **410** provides for phone line communications. A general purpose I/O interface **412** is provided for special discrete I/O functions. Additionally, the CPU module **400** has a serial interface to a bus interface module (BIM) **414** used to connect to the EIB bus **170**. As described, the EIB bus **170** is used as a connection means between the system controller **126** and each of the I/O controllers, such as **124**A, **124**B and **124**C. Alternatively, with the master I/O controller, such as described above relative to FIG. **5**, the system controller **126** is directly connected to the master I/O controller **124-1** and connections between I/O controllers is via the EIB bus **170**. In order to configure an EIB device, an EIB switch and LED **416** are used to locate and address the device. The protocol on this bus conforms to the Konnex standard.

The CPU module **400** also includes an LCD/touch pad interface **418** for driving the user interface **154** comprising the touchscreen **128** and LCD **130**, see FIG. **3**. This interface **418** allows a user to interact with the system controller **126**. The LCD **130** is a 5.1" diagonal monochrome graphical device. Alternatively, a color display could be used. The display **130** includes an LED back light. A contrast adjustment circuit **420** is connected to the interface **418** and may consist of a potentiometer, or the like. The touchscreen **128** is a standard four wire type device. The combination of an LCD **130** and touchscreen **128** provides improvement over use of limited keys or buttons and small text only displays.

In order to accommodate memory requirements, a compact flash socket **422** is connected to the CPU module **400** to allow for memory expansion.

The communication from the system controller **126** to an I/O controller **124**, includes configuration information such as input types, output types, input/output mapping, schedules and normal group addressing information. The system controller **126** receives status information on remote operated devices **110** from the I/O controllers **124**. The system controller **126** sends on and off commands to the I/O controllers **124** using group addresses in EIB. The I/O controllers **124** send input change notices to the system controller **126** when any input changes state and reports back to the system controller **126**, on request, all or part of received information, for verification.

More particularly, each I/O controller microcontroller **146**, see FIGS. **4** and **6**, implements an I/O board application program which is a combination of standard table definitions and specialized code for handling the inputs and/or outputs. An EIB stack handles all communications with the EIB network **170** and notifies the application program of any EIB requests. Also, software is included for communicating with the remote operated devices **110**.

The application program is notified when an output needs to be turned on or off. The code can then write directly to ports **304** or **306**, see FIG. **6**, to effect the opening/closing of a remote operated device **110**. Similarly, in a cyclic loop, the application can check the status of inputs and update the appropriate EIB tables to reflect the state of the inputs. To handle multi-part activities, a scheduler is provided within the application program. The scheduler will keep track of tasks that must be accomplished either in the next cyclic loop or after a certain elapsed time or at a certain time of day.

The application program includes a set of required tables to drive the EIB stack. These tables are an address table, an association table, communication objects, and parameters for the communication objects. When a particular EIB device is programmed, these tables are downloaded and determine how the device responds to particular EIB messages. Each of the forty-two outputs need communication objects defined for at least status and force control, and optionally manual override, control and logic. The control, logic and manual override objects are driven by the discrete inputs. Thus, they may or may not need a communication object defined. Each of the thirty-two discrete inputs needs one communication object defined.

The system controller **126** functions as the configurator and master to all of the panels **100**. Apart from configuration, it also tests, diagnoses, and reports device activities for each of up to eight panels **100**. The system controller software runs on a window CE operating system.

A user interface application is a Windows forms application which makes calls to all the business objects on an on-demand basis. This application uses the touch panel interface **154** to drive the application. A schedule manager runs all the time and initiates necessary events when the time to trigger reaches. This object handles all events and treats them based on whether they are scheduled events or manual events. A synchronization manager is a time sync object that runs all the time and synchronizes the clocks with all of the panels **100** and the system controller **126**. A communications handler accepts all requests from the user interface or from other business objects, such as the schedule manager, and dispatches these requests to the appropriate protocol handler. A group address provider provides to a caller a unique group address, keeping in kind the general group address architecture. Group addresses are used primarily for establishing zones of lights or addressing individual inputs or outputs. A physical address provider provides to a caller a unique physical address based on a given panel number. One unique physical address is assigned to each panel in a system. In general, the physical address is the unique address by which an EIB device can be programmed.

An EIB handler performs the functions of taking requests from the communication handler and sending them out to the EIB network and responding to any EIB messages received from the EIB network. The EIB handler takes a logical request from the communications handler and translates it into the appropriate message type for EIB and assigns the necessary addressing to it, based on the panel ID or on the group address. For received EIB messages, the EIB handler reverses this process, by interpreting the message type back into a generic response and translating the address into a panel ID or leaving it as a group address. Then it determines if this received message is an expected response or if it is an unsolicited response. Unsolicited responses are queued up waiting for the communication handler to ask for them.

Thus, in accordance with the invention, an integrated electrical power distribution system, such as a lighting control system, includes a system controller for plural integrated distribution panels in an electrical power distribution system. This provides each panel **100** with direct control of individual remote operated devices **110**, with supervisory capability from a single system controller **126** in an integrated system.

The present invention has been described with respect to flowcharts and block diagrams. It will be understood that each block of the flowchart and block diagrams can be implemented by computer program instructions. These program instructions may be provided to a processor to produce a machine, such that the instructions which execute on the processor create means for implementing the functions specified in the blocks. The computer program instructions may be executed by a processor to cause a series of operational steps to be performed by the processor to produce a computer implemented process such that the instructions which execute on the processor provide steps for implementing the functions specified in the blocks. Accordingly, the illustrations support combinations of means for performing a specified function and combinations of steps for performing the specified functions. It will also be understood that each block and combination of blocks can be implemented by special purpose hardware-based systems which perform the specified functions or steps, or combinations of special purpose hardware and computer instructions.

We claim:

1. An electrical distribution system for selectively connecting an electrical power source to load devices, comprising:

a plurality of panels, each panel comprising a plurality of switching devices mounted in the panel, each switching device for connection in a branch circuit to a load device for selectively delivering electrical power to the load device, and an input/output (I/O) controller mounted in the panel and operatively connected to each of the switching devices, wherein the I/O controller implements standard table definitions and specialized code for directly controlling operation of the switching devices, the I/O controller including a communication circuit; and

a system controller connected to each I/O controller communication circuit and comprising a programmed controller for commanding operation of the I/O controllers.

2. The electrical distribution system of claim **1** wherein the system controller is operable to independently configure operation of each of the I/O controllers.

3. The electrical distribution system of claim **1** wherein the system controller is operable to download commands to each of the I/O controllers to control operation of individual select ones of the plurality of remote operated devices.

4. The electrical distribution system of claim **1** wherein the system controller is operable to download commands to each of the I/O controllers to control operation of a plurality of the remote operated devices in a zone configuration.

5. The electrical distribution system of claim **1** wherein the system controller comprises a user interface for configuring operation of the I/O controllers.

6. The electrical distribution system of claim **5** wherein the user interface displays information from the plurality of panels in a graphical display.

7. The electrical distribution system of claim **1** wherein the system controller is mounted in one of the plurality of panels.

8. The electrical distribution system of claim **1** wherein the programmed controller comprises a communication circuit for communication with external networks.

9. An electrical distribution system for selectively connecting an electrical power source to load devices, comprising:

a plurality of panels, each panel comprising a plurality of switching devices mounted in the panel, each switching device for connection in a branch circuit to a load device for selectively delivering electrical power to the load device, and an input/output (I/O) controller mounted in the panel and operatively connected to each of the switching devices, wherein the I/O controller develops commands for controlling operation of the switching devices, the I/O controller including a communication circuit; and

a system controller connected to each I/O controller communication circuit and comprising a programmed controller for commanding operation of the I/O controllers:

wherein the system controller is operable to download switching schedules to each of the I/O controllers.

10. An electrical distribution system for selectively connecting an electrical power source to load devices, comprising:

a plurality of panels, each panel comprising a plurality of switching devices mounted in the panel, each switching device for connection in a branch circuit to a load device for selectively delivering electrical power to the load device, and an input/output (I/O) controller mounted in the panel and operatively connected to each of the switching devices, wherein the I/O controller develops commands for controlling operation of the switching devices, the I/O controller including a communication circuit; and

a system controller connected to each I/O controller communication circuit and comprising a programmed controller for commanding operation of the I/O controllers:

wherein the system controller receives status information from each of the I/O controllers indicating operating condition of the plurality of the remote operated devices.

11. An electrical distribution system for selectively connecting an electrical power source to load devices, comprising:

a plurality of panelboards each having a plurality of load circuit positions, a plurality of pairs of circuit breakers and switching devices each mounted in one of the load circuit positions, and each pair electrically connected between an electrical power source and a load device for selectively delivering electrical power to load devices, and an input/output (I/O) controller mounted in the panelboard, wherein the I/O controller implements standard table definitions and specialized code for directly controlling operation of the switching devices, the I/O controller including a communication circuit; and

a system controller connected to each I/O controller communication circuit and comprising a programmed controller for commanding operation of the I/O controllers.

12. The electrical distribution system of claim **11** wherein the system controller is operable to independently configure operation of each of the I/O controllers.

13. The electrical distribution system of claim **11** wherein the system controller is operable to download commands to each of the I/O controllers to control operation of individual select ones of the plurality of remote operated devices.

14. The electrical distribution system of claim **11** wherein the system controller is operable to download commands to each of the I/O controllers to control operation of a plurality of the remote operated devices in a zone configuration.

15. The electrical distribution system of claim **11** wherein the system controller comprises a user interface for configuring operation of the I/O controllers.

16. The electrical distribution system of claim **15** wherein the user interface displays information from the plurality of panelboards in a graphical display.

17. The electrical distribution system of claim **11** wherein the system controller is mounted in one of the plurality of panelboards.

18. The electrical distribution system of claim **11** wherein the programmed controller comprises a communication circuit for communication with external networks.

19. An electrical distribution system for selectively connecting an electrical power source to load devices, comprising:

a plurality of panelboards each having a plurality of load circuit positions, a plurality of pairs of circuit breakers and switching devices each mounted in one of the load circuit positions, and each pair electrically connected between an electrical power source and a load device for selectively delivering electrical power to load devices, and an input/output (I/O) controller mounted in the panelboard, wherein the I/O controller develops commands for controlling operation of the switching devices, the I/O controller including a communication circuit; and

a system controller connected to each I/O controller communication circuit and comprising a programmed controller for commanding operation of the I/O controllers:

wherein the system controller is operable to download switching schedules to each of the I/O controllers.

20. An electrical distribution system for selectively connecting an electrical power source to load devices, comprising:

a plurality of panelboards each having a plurality of load circuit positions, a plurality of pairs of circuit breakers and switching devices each mounted in one of the load circuit positions, and each pair electrically connected between an electrical power source and a load device for selectively delivering electrical power to load devices, and an input/output (I/O) controller mounted in the panelboard, wherein the I/O controller develops commands for controlling operation of the switching devices, the I/O controller including a communication circuit; and

a system controller connected to each I/O controller communication circuit and comprising a programmed controller for commanding operation of the I/O controllers;

wherein the system controller receives status information from each of the I/O controllers indicating operating condition of the plurality of the remote operated devices.

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